Natural Conditions Assessment for low pH Piscataway Creek Essex County, Virginia

Submitted by

Virginia Department of Environmental Quality

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Executive Summary

This report presents the development of a pH Total Maximum Daily Load (TMDL) for the Piscataway Creek watershed. The Piscataway Creek watershed is located in Essex County in the Rappahannock River Basin (USGS Hydrologic Unit Code 02080104). The waterbody identification code (WBID, Virginia Hydrologic Unit) for Piscataway Creek is VAP-E23R and VAP-E23E in the Coastal Plain region of Virginia.

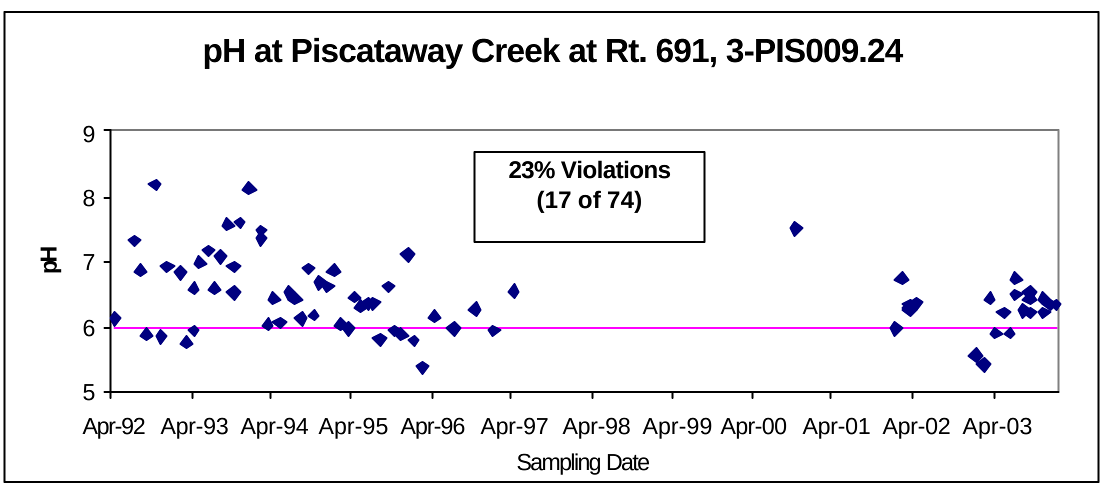
There are 83.4 total stream miles in the Piscataway watershed (National Hydrography Dataset (NHD), of which 8.20 miles are tidal, encompassing 0.71 square miles. The three impaired segments are 3.5 miles in mainstem Piscataway Creek, 2.58 miles in an unnamed tributary to Piscataway Creek, and 0.71 square miles of tidal Piscataway Creek. The impairment for each segment is low pH.

The drainage area of the Piscataway Creek watershed is approximately 57.4 square miles. The average annual rainfall recorded at Warsaw, VA (within the study area) is 43.04 inches. The approximately 36,738 acre watershed is predominately forested (63.1 percent). Agriculture encompasses 26.5 percent of the watershed, with 16.1 percent cropland and 10.4 pasture/hayland. Residential and commercial areas compose approximately 0.3 percent of the land base. The remaining 10.0 percent of the watershed is comprised of 5.4 percent transitional and other grasses, and 4.6 percent wetlands and open water.

Piscataway Creek and an unnamed tributary of Piscataway Creek were listed as impaired on Virginia's 1998 and 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2002 & 2004) due to violations of the State's water quality standard for pH. This report evaluates the pH impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

Out of 74 pH values collected between April 1992 and January 2004, at station 3-PIS009.24, 17 were below the lower water quality standard for pH of pH 6 SU. (Figure E1).

Figure E1. pH at Piscataway Creek at Rt. 691, 3-PIS009.24, April 1992 to January 2004.



According to Virginia Water Quality Standards (9 VAC 25-260-10A), "all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."

As indicated above, Piscataway Creek must support all designated uses by meeting all applicable criteria. The Piscataway Creek has been assessed as not supporting the aquatic life use due to the exceedance of the pH criteria that are designed to protect aquatic life in Class III waters.

In this document, VADEQ proposes a "Methodology for Determining if pH and DO Impairments in Streams are Due to Natural Conditions." This methodology is based on a study done by MapTech (MapTech 2003) and will be used here to determine if the pH impairments in Piscataway Creek are natural and if Piscataway Creek can be re-classified as Class VII (Swamp Waters).

The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

Piscataway Creek exhibits low slope with significant wetlands, and large areas of forested land. These contribute large inputs of decaying vegetation, which produce organic acids and lower pH as they decay. These are not considered anthropogenic impacts.

Piscataway Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which are not indicative of human impact.

There are no permitted dischargers in the Piscataway Creek watershed. Residential / Commercial land use (0.3%) in the northeastern part of the watershed probably has no pH effect on the headwaters or tidal areas.

There is not a close correlation between precipitation amounts and field pH at DEQ ambient water quality monitoring stations. The only discernable pattern has been a general negative correlation of precipitation to pH and the majority of r-values were well below 0.5, which does not indicate a close correlation between the variables. However the extent to which stream pH is decreased by acid deposition cannot be conclusively determined.

Based on the above findings, a change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Piscataway Creek and its tributaries from their headwaters to the confluence with the Rappahannock River. If there is a 305(b)/303(d) assessment prior to the reclassification, Piscataway Creek will be assessed as Category 4C, Impaired due to natural condition, no TMDL needed.

DEQ performed the assessment of the Piscataway Creek low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

1. Introduction

Piscataway Creek and an unnamed tributary to Piscataway Creek were listed as impaired on Virginia's 1998 303(d) Total Maximum Daily Load Priority List and Report, 2002 303(d) Report on Impaired Waters, and 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2002 & 2004) due to violations of the State's water quality standard for pH. This report evaluates the pH impairment by determining if natural conditions are the cause of the impairment, thus obviating the need for a TMDL.

2. Physical Setting

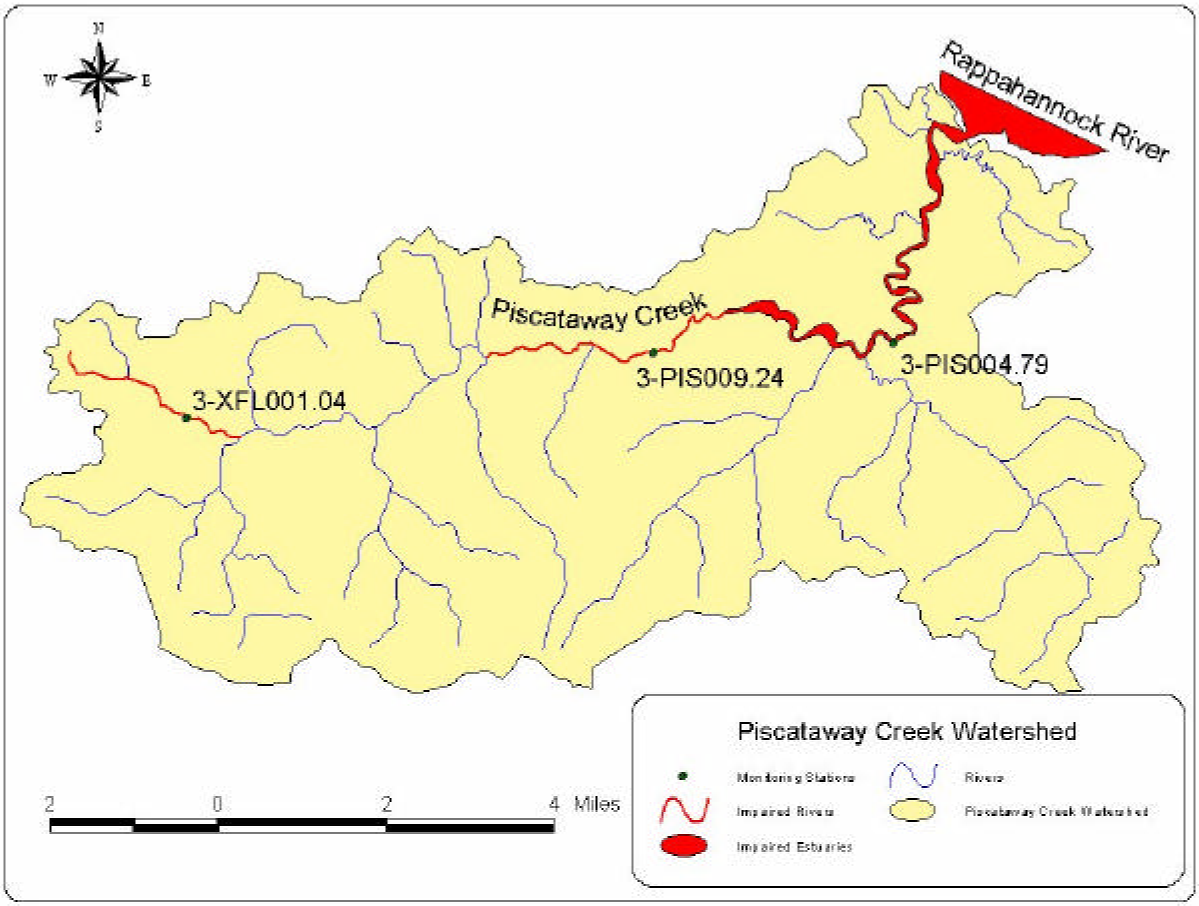
2.1. Listed Water Bodies

Piscataway Creek is located in Essex County in the Rappahannock River Basin (USGS Hydrologic Unit Code 02080104). The waterbody identification code (WBID, Virginia Hydrologic Unit) for Piscataway Creek is VAP-E23E (tidal) and VAP-E23R (non-tidal). There are 83.4 total stream miles in the Piscataway watershed (National Hydrography Dataset (NHD), of which 8.20 miles are tidal, encompassing 0.71 square miles. The three impaired segments are 3.5 miles in mainstem Piscataway Creek, 2.58 miles in an unnamed tributary to Piscataway Creek, and 0.71 square miles of tidal Piscataway Creek, as described in Table 1 and Figure 1. The impairment for each segment is low pH.

Table 1. Impaired segment descriptions (Piscataway Creek)

Segment (segment ID)	Impairment (source of impairment)	Upstream Limit Description	Downstream Limit Description	Miles Affected
Piscataway Creek VAP-E23E-04	pH (unknown)	Head of tide at RM 8.20	Rappahannock River confluence	0.71 mi^2
Piscataway Creek VAP-E23R-03	pH (unknown)	Sturgeon Creek confluence	Head of tide at RM 8.20	3.50 miles
Piscataway Creek VAP-E23R-08	pH (unknown)	Headwaters	Piscataway Creek confluence	2.58 miles

Figure 1. Map of the Piscataway Creek study area.



2.2. Watershed

2.2.1. General Description

Piscataway Creek, located entirely within Essex County, is a minor tributary to the Rappahannock River. It is about 17 miles long and flows eastward from its headwaters west of Tappahannock, VA. to its confluence with the Rappahannock River. The watershed itself is approximately 13 miles long and 5 miles wide, having an area of 57.4 square miles. The major tributaries to Piscataway Creek are Sturgeon Swamp and Mussell Swamp, which enter from south, and two unnamed tributaries, which enter from the west near the headwaters. There is a continuous flow gaging station on Piscataway Creek, 01669000 Tappahannock Creek near Tappahannock, VA., at Rt. 691, with a drainage area of 28.0 mi^2.

2.2.2. Geology, Climate, Land Use

Geology and Soils

Piscataway Creek is in the Atlantic Coastal Plain physiographic region. The Atlantic Coastal Plain is the easternmost of Virginia's physiographic provinces. The Atlantic Coastal Plain extends from New Jersey to Florida, and includes all of Virginia east of the Fall Line. The Fall Line is the easternmost extent of rocky river rapids, the point at which east-flowing rivers cross from the hard, igneous and metamorphic rocks of the Piedmont to the relatively soft, unconsolidated strata of the Coastal Plain. The Coastal Plain is underlain by layers of Cretaceous and younger clay, sand, and gravel that dip gently eastward. These layers were deposited by rivers carrying sediment from the eroding Appalachian Mountains to the west. As the sea level rose and fell, fossiliferous marine deposits were interlayered with fluvial, estuarine, and beach strata. The youngest deposits of the Coastal Plain are sand, silt and mud presently being deposited in our bays and along our beaches (http://www.geology.state.va.us/DOCS/Geol/coast.html).

Soils for the Piscataway Creek watershed were documented utilizing the VA State Soil Geographic Database (STATSGO). Two general soil types were identified using in this database. Descriptions of these soil series were derived from queries to the USDA Natural Resources Conservation Service (NRCS) Official Soil Series Description web site (http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi). Figure 2 shows the location of these general soil types in the watershed.

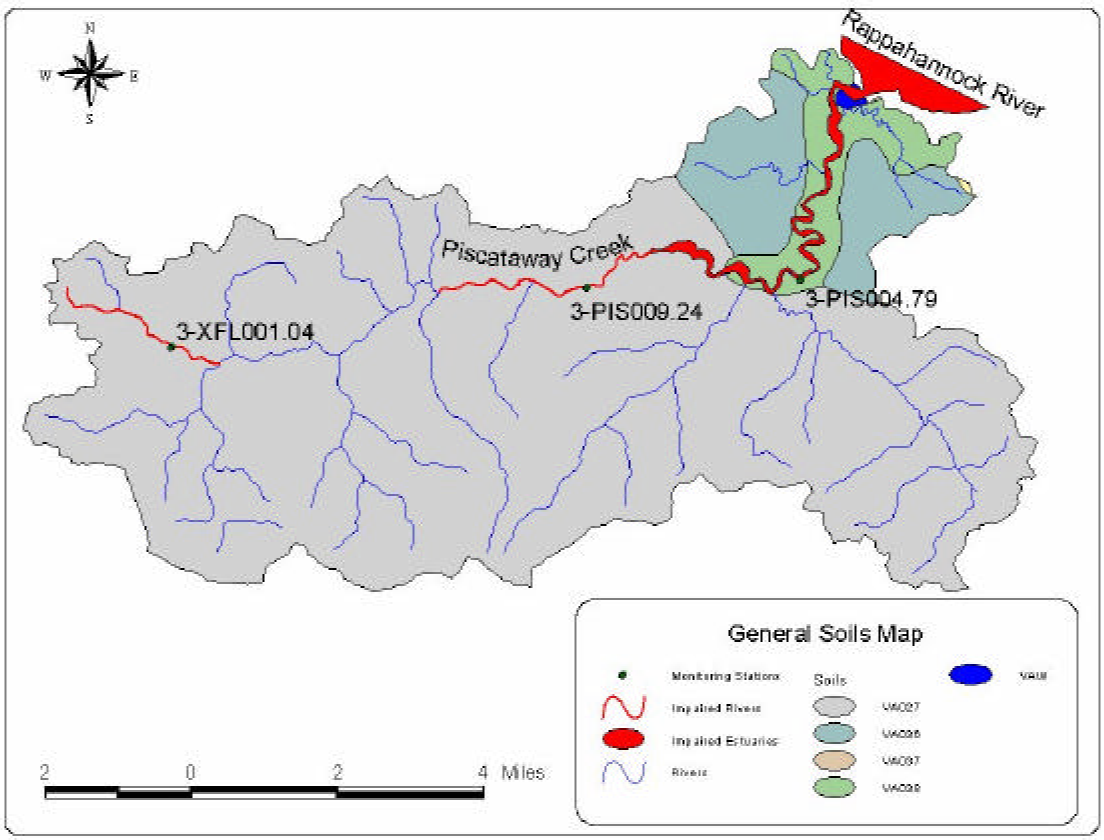
Soils of the Emporia-Johnston-Kenansville-Remlik-Rumford-Slagle-Suffolk-Tomotley (VA027) series are very deep to deep, and vary between well drained to poorly drained with moderately slow or slow permeability. They formed in moderately fine-textured stratified fluvial and marine sediments on the upper Coastal Plain and stream terraces.

Soils of the Tetotum-Nansemond-State-Emporia-Dragston-Nimmo-Bladen Series (VA036) are very deep and range from well drained to poorly drained. Permeability ranges from moderately rapid and/or rapid to moderately slow or slow. This soil series was formed in sandy or loamy fluvial and marine sediments on Coastal Plain uplands and stream terraces.

The Portsmouth - Roanoke -Rains - Eunola - Levy - Kalmia Series (VA037) are very deep, very poorly to moderately well drained soils. These soils are located on low stream or marine terraces and in marshes of the Atlantic Coastal Plain. These series are formed from fluvial and marine sediments. Permeability of these soil types ranges from very slow to rapid, depending on soil composition.

The Pamunkey-Nansemond-Bibb-Kinston-Nawney-Bohicket Series (VA038) are very deep, poorly to well drained soils, and range from well to moderately well to slow permeability. These soils are located on low stream or marine terraces and in the flood plains in the Piedmont and the Coastal Plain Physiograph Provinces. These soil series are formed in fine to coarse loamy marine and fluvial sediments and sandy alluvium.

Figure 2. Soil Characteristics of the Piscataway Creek Watershed.



Climate

The climate summary for Piscataway Creek comes from a weather station located in Warsaw, VA, with a period of record from 1/ 1/1951 to 3/31/2004. The average annual maximum and minimum temperature (°F) at the weather station is 68.7 and 46.9 and the annual rainfall (inches) is 43.04 (Table 2) (Southeast Regional Climate Center, http://www.sercc.com/climateinfo/historical/historical_va.html).

Table 2. Climate summary for Warsaw, Virginia (448894)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	46.4	50.0	58.4	69.5	77.5	85.1	88.8	87.1	81.1	70.7	60.3	49.8	68.7
Average Min. Temperature (F)	27.4	29.5	36.0	44.9	54.0	62.4	67.0	65.6	58.7	47.4	39.0	30.9	46.9
Average Total Precipitation (in.)	3.14	2.81	3.83	2.98	4.12	3.56	4.49	4.38	4.13	3.34	3.16	3.11	43.04

Land Use

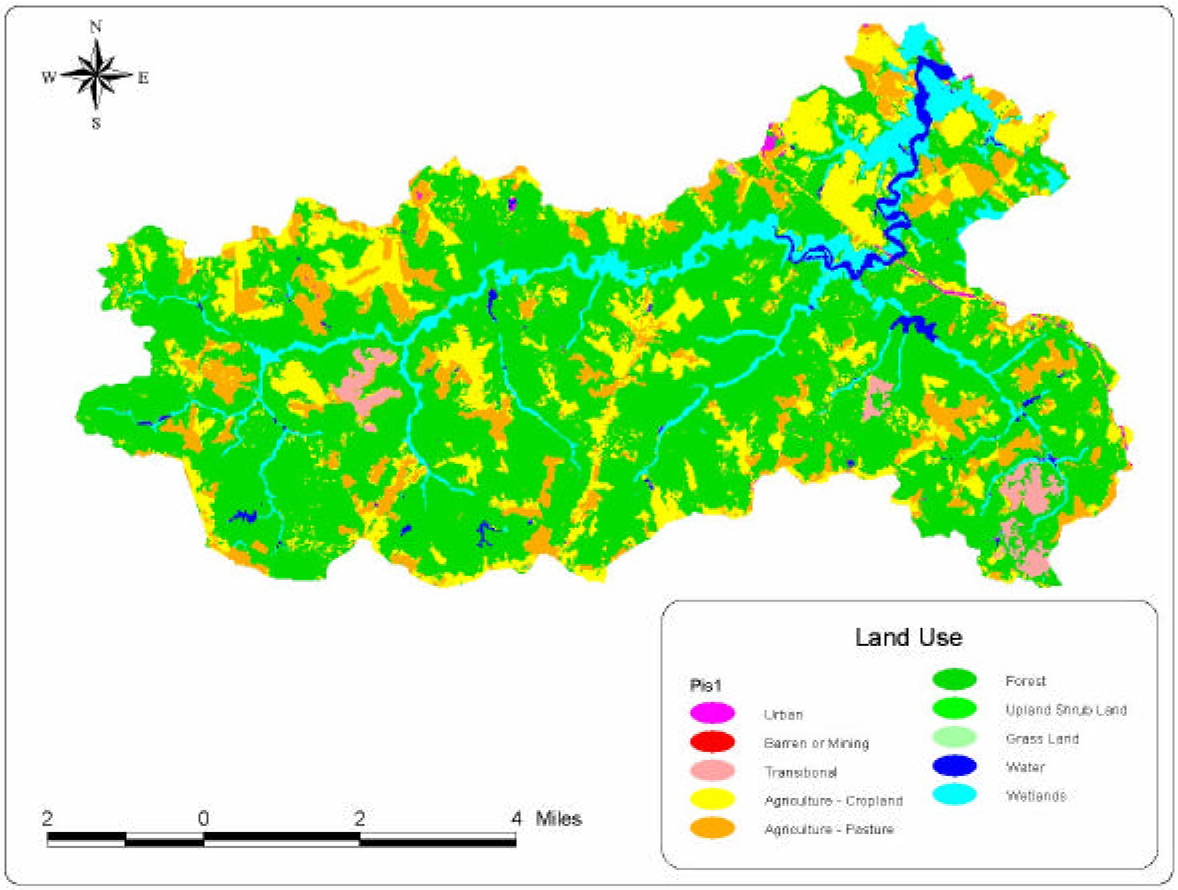
The Piscataway Creek watershed extends approximately 13 miles upstream from the stream's confluence with the Rappahannock River and is approximately 5 miles wide. The approximately 36,738 acre watershed is predominately forested (63.0 percent). Agriculture encompasses 26.5 percent of the watershed, with 16.1 percent cropland and 10.4 pasture/hayland. Residential and high use industrial areas compose approximately 0.3 percent of the land base. The remaining 10.0 percent of the watershed is comprised of 5.4 percent of transitional areas and grasses, and 4.64 percent wetlands and open water. Land use is described in Table 3.

A map of the distribution of land use in the watershed (Figure 3) shows that urban land is found in the northeastern portions of the watershed. Agriculture and forest land are scattered throughout the watershed.

Table 3. Land Use in the Piscataway Creek Watershed

Landuse	Acres	Percent (% Acre)
Open Water	514.6	1.40
Low Intensity Residential	13.6	0.04
High Intensity Residential	0.0	0.00
High Intensity Commercial/Industrial/Transportation	101.6	0.28
Bare Rock/Sand/Clay	0.0	0.00
Quarries/Strip Mines/Gravel Pits	0.0	0.00
Transitional	590.2	1.61
Deciduous Forest	9571.4	26.05
Evergreen Forest	2968.7	8.08
Mixed Forest	10648.7	28.99
Pasture/Hay	3823.2	10.41
Row Crops	5929.9	16.14
Other Grasses (Urban/recreational; e.g. parks)	0.0	0.00
Woody Wetlands	1386.2	3.77
Emergent Herbaceous Wetlands	1190.3	3.24
Total:	36738.5	100.00
	57.4 sq. mi.	

Figure 3. Land Use in the Piscataway Creek Watershed.



3. Description of Water Quality Problem/Impairment

Piscataway Creek and an unnamed tributary of Piscataway Creek were listed as impaired on Virginia's 1998 and 2002 303(d) Total Maximum Daily Load Priority List and Report, and the 2004 305(b) / 303(d) Integrated Report (VADEQ, 1998, 2002 & 2004) due to violations of the State's water quality standard for pH. Out of 74 pH values collected between April 1992 and January 2004 at station 3-PIS009.24, (Figure 4), 17 were below the lower water quality standard for pH of pH 6 SU (Figure 5 and Table 4).

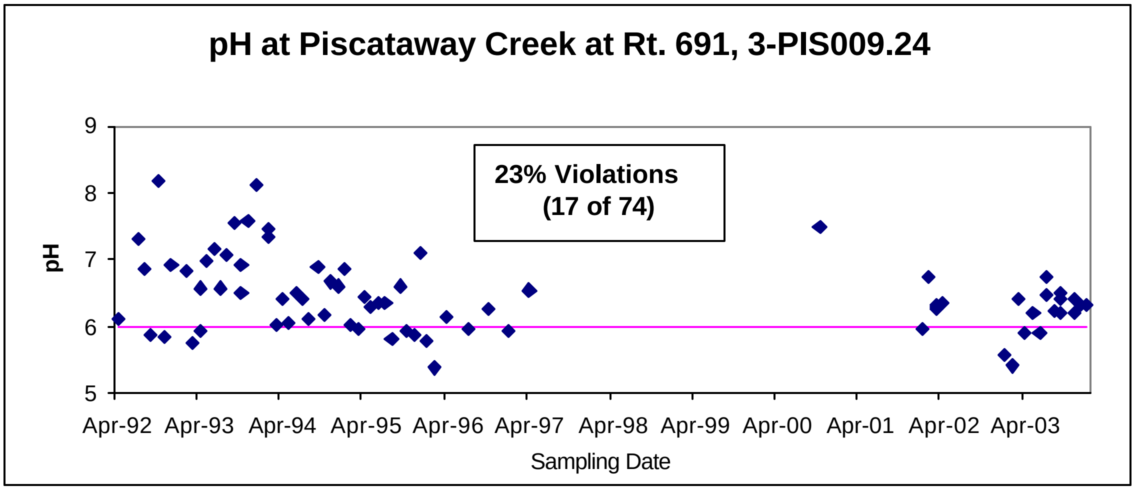
Table 4. pH data collected by DEQ on Piscataway Creek

				(SU)			
Station	**Date of First Sample**	**Date of Last Sample**	**Number of Samples**	**Average**	**Minimum**	**Maximum**	**Number of Exceed-ances***
3-PIS009.24	04/06/1992	01/20/2004	74	6.49	5.36	8.16	17

* Exceedances of the minimum pH water quality standard of pH 6.0 SU.

A time series graph of all data collected at station 3-PIS009.24 shows the pH values ranging from pH 5.36 to 8.16 SU (Figure 4). The horizontal line at the pH 6 SU marks represents the minimum water quality standard. The data points below the pH 6.0 SU line illustrate violations of the water quality standard.

Figure 4. Time series of pH concentrations (station 3-PIS009.24).



3.1 Associated Mainstem and Tributary site pH

DEQ added several associated mainstem and tributary monitoring stations during data collection for the low pH assessment of natural conditions or development of a TMDL. Associated station pH data are presented in Figures 5 - 15 below.

Figure 5. pH at Sturgeon Swamp at Rt. 642, 3-STU000.92.

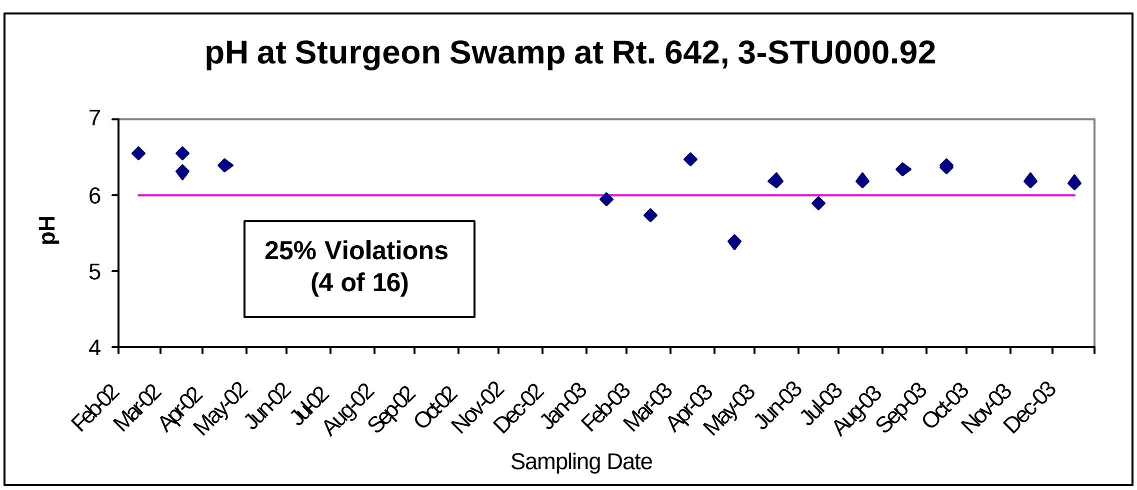


Figure 6. pH at UT Piscataway Creek, mouth 60 M above Rt. 620, 3-XFN000.01.

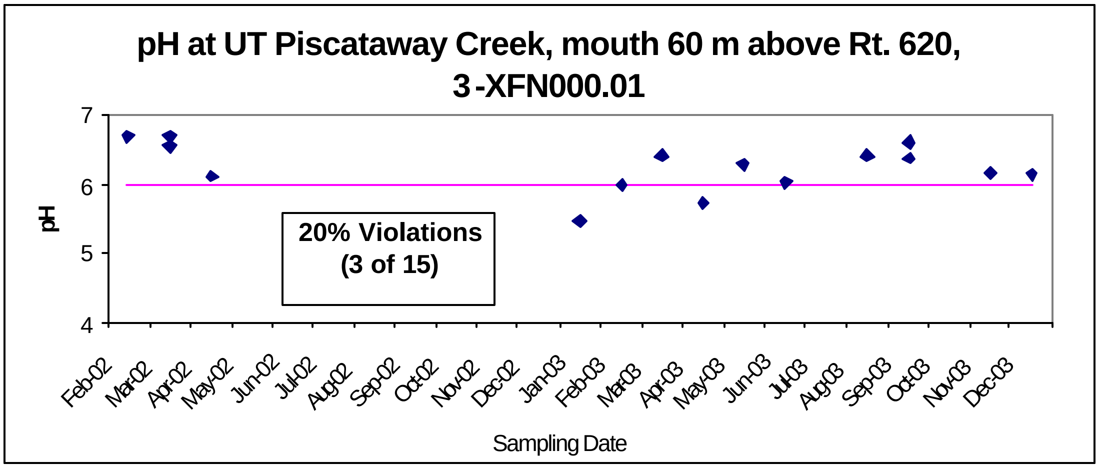


Figure 7. pH at Piscataway Creek at Rt. 620, 3-PIS013.85.

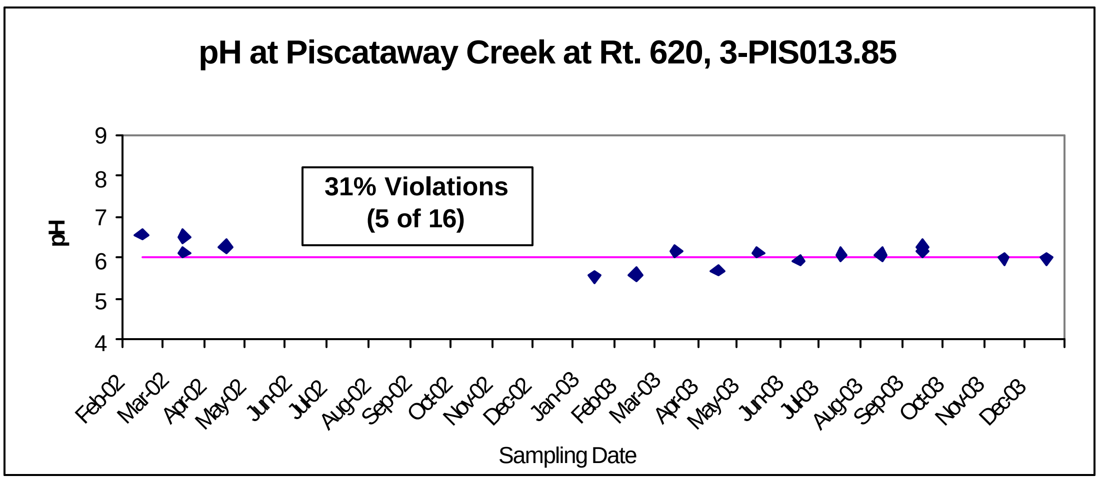


Figure 8. pH at Piscataway Creek at Rt. 622, 3-PIS014.13.

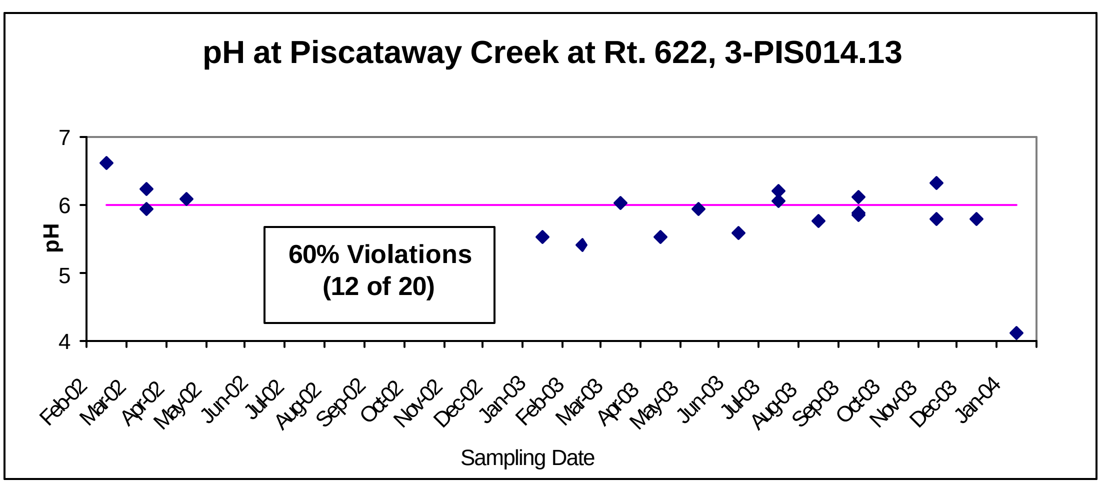


Figure 9. pH at UT Piscataway Creek at Rt. 623, 3-XFM000.82.

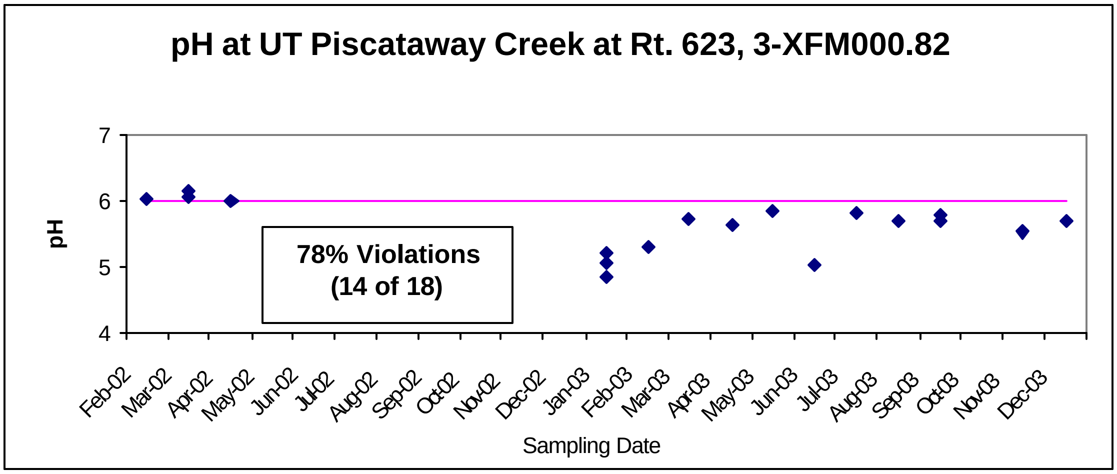


Figure 10. pH at UT Piscataway Creek at Rt. 650, 3-XFL001.04.

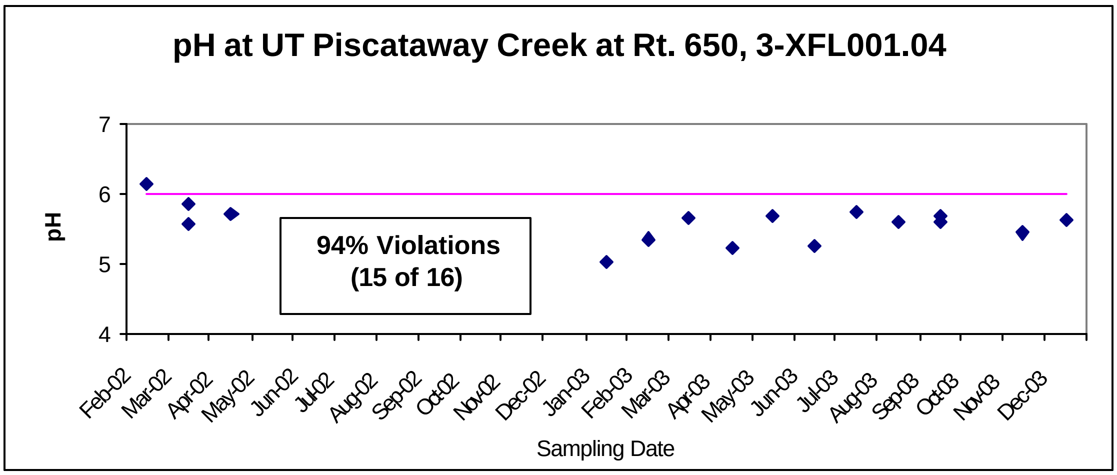
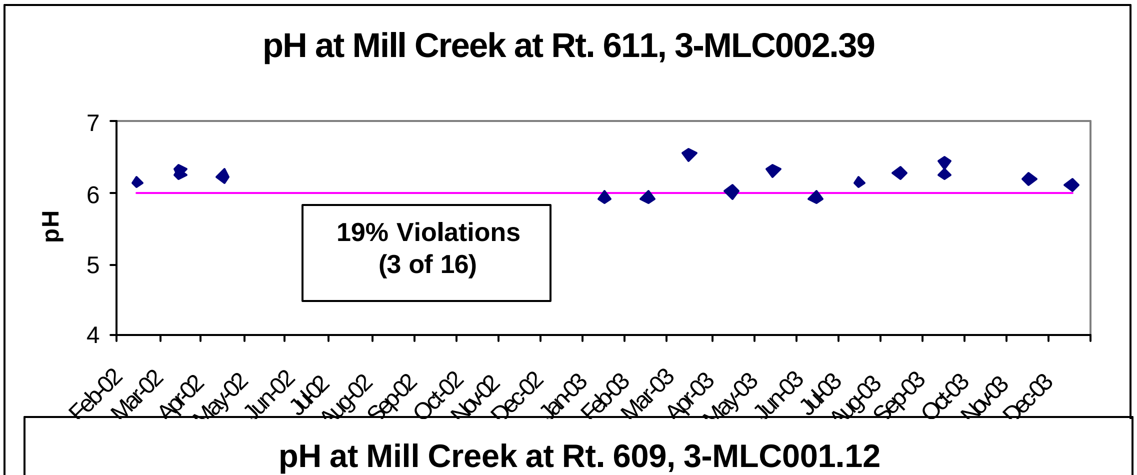


Figure 11. pH at Mill Creek at Rt. 609, 3-MLC001.12.

Figure 12. pH at Mill Creek at Rt. 611, 3-MLC002.39.



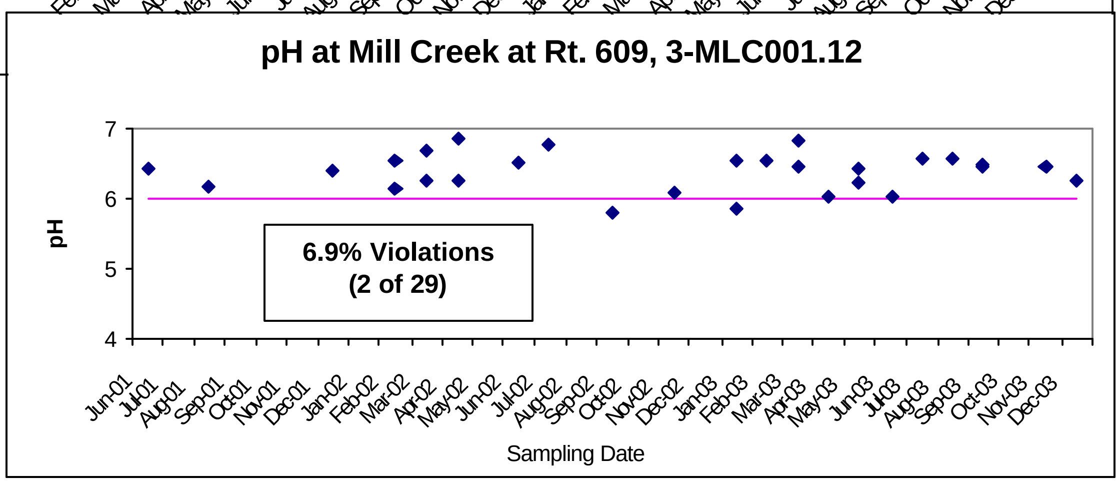


Figure 13. pH at Mussell Swamp at Rt. 615, 3-MUS001.23.

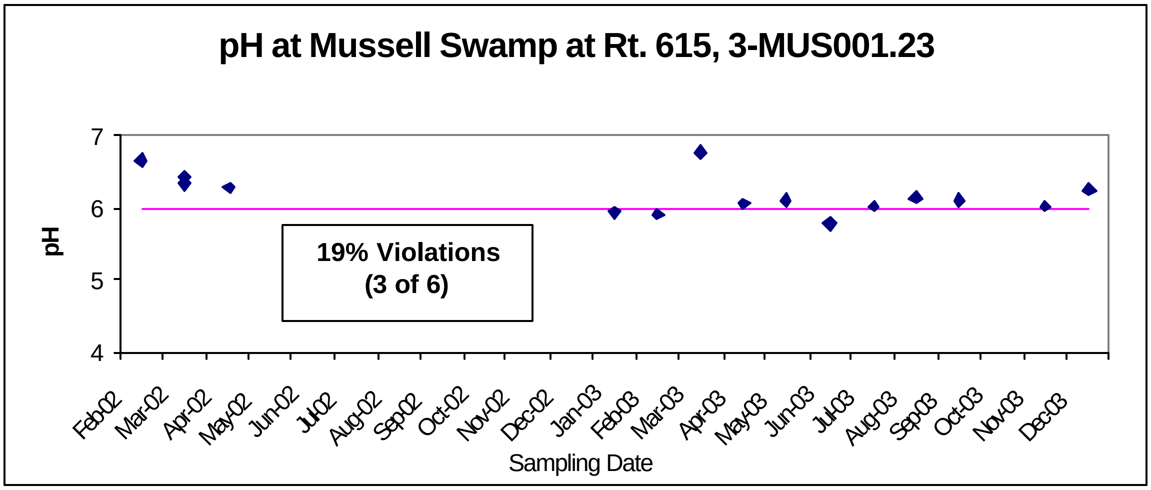


Figure 14. pH Tidal Piscataway Creek at end of Rt. 616,3-PIS000.12.

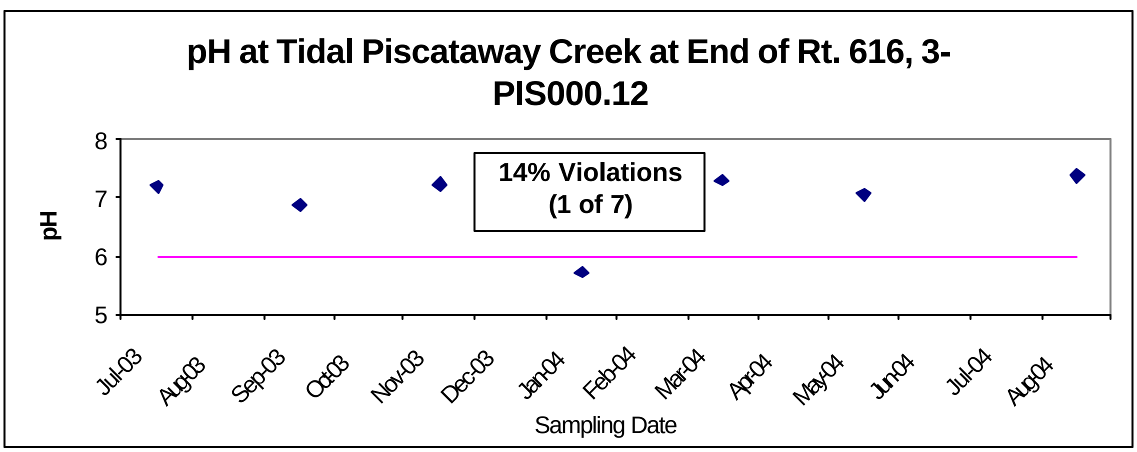
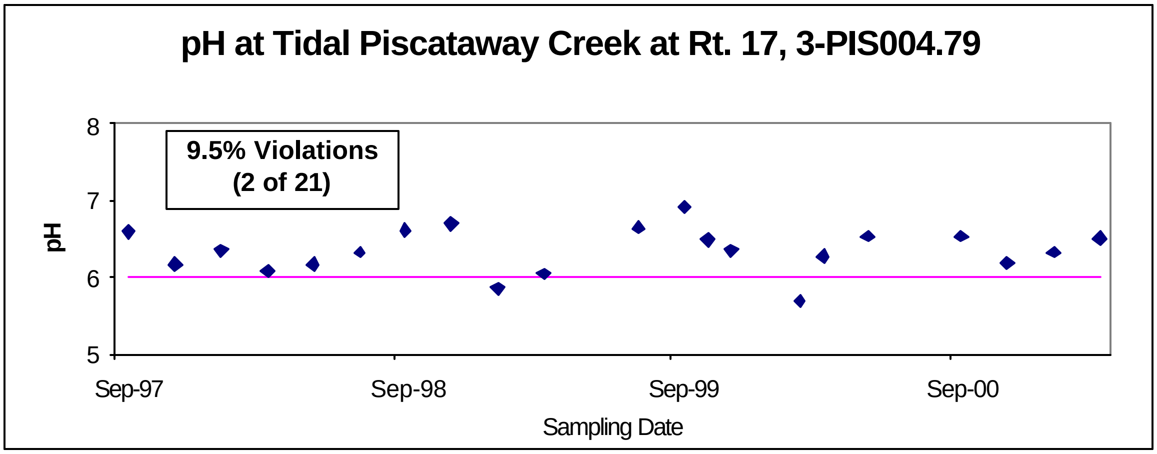


Figure 15. pH Tidal Piscataway Creek at Rt. 17, 3-PIS004.79.



4. Water Quality Standard

According to Virginia Water Quality Standards (9 VAC 25-260-5), the term *"water quality standards means provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC §1251 et seq.)."*

As stated above, Virginia water quality standards consist of a designated use or uses and a water quality criteria. These two parts of the applicable water quality standard are presented in the sections that follow.

4.1. Designated Uses

According to Virginia Water Quality Standards (9 VAC 25-260-10A), *"all state waters are designated for the following uses: recreational uses (e.g., swimming and boating); the propagation and growth of a balanced indigenous population of aquatic life, including game fish, which might be reasonably expected to inhabit them; wildlife; and the production of edible and marketable natural resources (e.g., fish and shellfish)."*

As stated above, Piscataway Creek must support all designated uses by meeting all applicable criteria. Piscataway Creek has been assessed as not supporting the aquatic life use due to the exceedance of the pH criteria that are designed to protect aquatic life in Class III waters.

4.2. Applicable Water Quality Criteria

The Class III water quality criteria for pH in the Piscataway Creek watershed is a minimum pH 6 SU and a maximum pH 9.0 SU (Table 5).

Table 5. Applicable water quality standards

Parameter	Minimum pH SU	Maximum pH SU
pH	6.0	9.0

If the waterbody exceeds the criterion listed above in more than 10.5 percent of samples, the waterbody is classified as impaired and a TMDL must be developed and implemented to bring the waterbody into compliance with the water quality criterion. However, in the case of Piscataway Creek there is reason to believe that the waterbody has been mis-classified and that the apparent impairment is due to the swampy nature of the stream. In this document, VADEQ applies a proposed methodology for determining if DO and pH impairments in free-flowing streams are due to natural conditions. This methodology is based on a study done by MapTech in the Appomattox River Basin (MapTech 2003) and will be used here to determine if the pH impairments in Piscataway Creek are natural and if Piscataway Creek can be re-classified as Class VII (Swamp Waters).

5. Methodology for Natural Conditions Assessment

The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity. Conditions in a stream that would typically be associated with naturally low pH include slow-moving, ripple-less waters or wetlands where the decay of organic matter produces organic acids. These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems. The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below.

Step 1. Determine slope and appearance.
Step 2. Determine nutrient levels.
Step 3. Determine degree of seasonal fluctuation (for DO only).
Step 4. Determine anthropogenic impacts.

The results from this methodology (or process or approach) will be used to determine if the stream should be re-classified as Class VII Swamp Waters. Each step is described in detail below.

Procedure for Natural Condition Assessment of low pH and low DO in Virginia Streams

Prepared by Virginia Department of Environmental Quality
October 2004

I. INTRODUCTION

Virginia's list of impaired waters currently shows many waters as not supporting the aquatic life use due to exceedances of pH and/or DO criteria that are designed to protect aquatic life in Class III waters. However, there is reason to believe that most of these streams or stream segments have been mis-classified and should more appropriately be classified as Class VII, Swamp Waters. This document presents a procedure for assessing if natural conditions are the cause of the low pH and/or low DO levels in a given stream or stream segment.

The level of dissolved oxygen (DO) in a water body is determined by a balance between oxygen-depleting processes (*e.g.*, decomposition and respiration) and oxygen-restoring processes (*e.g.*, aeration and photosynthesis). Certain natural conditions promote a situation where oxygen-restoring processes are not sufficient to overcome the oxygen- depleting processes. The level of acidity as registered by pH in a water body is determined by a balance between organic acids produced by decay of vegetative material, and buffering capacity.

Conditions in a stream that would typically be associated with naturally low DO and/or naturally low pH include slow-moving, ripple-less waters. In such waters, the decay of organic matter depletes DO at a faster rate than it can be replenished and produces organic acids (tannins, humic and fulvic substances). These situations can be compounded by anthropogenic activities that contribute excessive nutrients or readily available organic matter to these systems.

The general approach to determine if DO and pH impairments in streams are due to natural conditions is to assess a series of water quality and hydrologic criteria to determine the likelihood of an anthropogenic source. A logical 4-step process for identifying natural conditions that result in low DO and/or pH levels and for determining the likelihood of anthropogenic impacts that will exacerbate the natural condition is described below. DEQ staff is proposing to use this approach to implement State Water Control Law 9 VAC 25-260-55, Implementation Procedure for Dissolved Oxygen Criteria in Waters Naturally Low in Dissolved Oxygen.

Waters that are shown to have naturally low DO and pH levels will be re-classified as Class VII, Swamp Waters, with the associated pH criterion of 4.3 to 9.0 SU. An associated DO criterion is currently being developed from swamp water data. A TMDL is not needed for these waters. An assessment category of 4C will be assigned until the waterbody has been re-classified.

II. NATURAL CONDITION ASSESSMENT

Following a description of the watershed (including geology, soils, climate, and land use), a description of the DO and/or pH water quality problem (including a data summary, time series and monthly data distributions), and a description of the water quality criteria that were the basis for the impairment determination, the available information should be evaluated in four steps.

<u>Step 1. Determine appearance and flow/slope.</u>

Streams or stream segments that have naturally low DO (< 4 mg/L) and low pH (< 6 SU) are characterized by very low slopes and low velocity flows (flat water with low reaeration rates). Decaying vegetation in such swampy waters provides large inputs of plant material that consumes oxygen as it decays. The decaying vegetation in a swamp water also produces acids and decreases pH. Plant materials contain polyphenols such as tannin and lignin. Polyphenols and partially degraded polyphenols build up in the form of tannic acids, humic acids, and fulvic acids that are highly colored. The trees of swamps have higher polyphenolic content than the soft-stemmed vegetation of marshes. Swamp streams (blackwater) are therefore more highly colored and more acidic than marsh streams.

Appearance and flow velocity (or slope if flow velocity is not available) must be identified for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. This can be done through maps, photos, field measurements or other appropriate means.

Step 2. Determine nutrient levels.

Excessive nutrients can cause a decrease in DO in relatively slow moving systems, where aeration is low. High nutrient levels are an indication of anthropogenic inputs of nitrogen, phosphorus, and possibly organic matter. Nutrient input can stimulate plant growth, and the resulting die-off and decay of excessive plankton or macrophytes can decrease DO levels.

USGS (1999) estimated national background nutrient concentrations in streams and groundwater from undeveloped areas. Average nitrate background concentrations are less than 0.6 mg/L for streams, average total nitrogen (TN) background concentrations are less than 1.0 mg/L, and average background concentrations of total phosphorus (TP) are less than 0.1 mg/L.

Nutrient levels must be documented for each stream or stream segment to be assessed for natural conditions and potential re-classification as a Class VII swamp water. Streams with average concentrations of nutrients greater than the national background concentrations should be further evaluated for potential impacts from anthropogenic sources.

Step 3. Determine degree of seasonal fluctuation (for DO only).

Anthropogenic impacts on DO will likely disrupt the typical seasonal fluctuation seen in the DO concentrations of wetland streams. Seasonal analyses should be conducted for each potential Class VII stream or stream segment to verify that DO is depressed in the summer months and recovers during the winter, as would be expected in natural systems. A weak seasonal pattern could indicate that human inputs from point or nonpoint sources are impacting the seasonal cycle.

Step 4. Determine anthropogenic impacts.

Every effort should be made to identify human impacts that could exacerbate the naturally low DO and/or pH. For example, point sources should be identified and DMR data analyzed to determine if there is any impact on the stream DO or pH concentrations. Land use analysis can also be a valuable tool for identifying potential human impacts.

Lastly, a discussion of acid rain impacts should be included for low pH waters. The format of this discussion can be based either on the process used for the recent Class VII classification of several streams in the Blackwater watershed of the Chowan Basin (letter from DEQ to EPA, 14 October 2003). An alternative is a prototype regional stream comparison developed for Fourmile Creek, White Oak Swamp, Matadequin Creek and Mechumps Creek (all east of the fall line). The example analysis under IV in this document, or the example report prepared for Fourmile Creek, illustrate this approach. For streams west of the fall line, a regional stream comparison for 2004 analyses encompasses Winticomack, Winterpock, and Skinquarter Creeks.

<u>7Q10 Data Screen</u>

If the data warrant it, a data screen should be performed to ensure that the impairment was identified based on valid data. All DO or pH data that violate water quality standards should be screened for flows less than the 7Q10. Data collected on days when flow was < 7Q10 should be eliminated from the data set and the violation rate recalculated accordingly. Only those waters with violation rates determined days with flows > or = 7Q10 flows should be classified as impaired.

In some cases, data were collected when flow was 0 cfs. If the 7Q10 is identified as 0 cfs as well, all data collected under 0 cfs flow would need to be considered in the water quality assessment. In those cases, the impairment should be classified as 4C, Impaired due to natural conditions, no TMDL needed. However, a reclassification to Class VII may not always be appropriate.

III. NATURAL CONDITION CONCLUSION MATRIX

The following decision process should be applied for determining whether low pH and/or low DO values are due to natural conditions and justify a reclassification of a stream or stream segment as Class VII, Swamp Water.

If velocity is low or if slope is low (<0.50%) AND
If wetlands are present along stream reach AND
If no point sources or only point sources with minimal impact on DO and pH AND
If nutrients are < typical background

- average (= assessment period mean) nitrate less than 0.6 mg/L
- average total nitrogen (TN) less than 1.0 mg/L, and
- average total phosphorus (TP) are less than 0.1 mg/L AND

For DO: If seasonal fluctuation is normal AND
For pH: If nearby streams without wetlands meet pH criteria OR if no correlation between in-stream pH and rain pH,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment

→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

The analysis must state the extent of the natural condition based on the criteria outlined above. A map showing land use, point sources, water quality stations and, if necessary, the delineated segment to be classified as swamp water should be included.

In cases where not all of these criteria apply, a case by case argument must be made based on the specific conditions in the watershed.

6. Natural Conditions Assessment for Piscataway Creek

6.1 Slope and Appearance

The hydrologic slope from the 50 ft topo contour at rivermile 15.17 one mile above Rt. 622 downstream to the 5 ft contour at rivermile 9.24 at Rt. 691 is estimated at 0.14%, considered low slope. The low slope is not indicative of human impact.

Visual inspection at bridges at Rts. 691, 620, 623, 17, and 616 revealed large swamps, tidal marshes and/or forested areas with heavy tree canopy (Figures 16 – 20). There are large inputs of decaying vegetation from areas of swamp, marshes and forested land with heavy tree canopy throughout the watershed, that produce acids and lower pH as they decay.

Figure 16. Piscataway Creek at Rt. 691.

Figure 17. Piscataway Creek at Rt. 620.

Figure 18. Piscataway Creek at Rt. 623.

Figure 19. Tidal Piscataway Creek at Rt. 17.

Figure 20. Tidal Piscataway Creek at Rt. 616 with wetlands in background.

6.2 Instream Nutrients

The VADEQ collected nutrient data from station 3-PIS009.24 from April 1992 to January 2004. The average nutrient concentrations are below the USGS (1999) national background nutrient concentrations in streams from undeveloped areas levels of nitrate < 0.6 mg/l; TN (TKN + NO_3 + NO_2) < 1.0 mg/l; and TP < 0.1 mg/l. These low nutrient levels are not indicative of human impact.

Parameter	Average Conc.	Number
Total Phosphorous	**0.092 mg/l**	(n=59)
Orthophosphorous	0.060 mg/l	(n=53)
Total Kjeldahl Nitrogen	0.421 mg/l	(n=52)
Ammonia as N	0.040 mg/l	(n=53)
Nitrate as N	**0.292 mg/l**	(n=50)
Nitrite as N	0.010 mg/l	(n=50)
TN (TKN + NO_3 + NO_2)	**0.716 mg/l**	(n=54)

6.3 Impact from Point Source Dischargers and Land Use

There are no permitted dischargers in the Piscataway Creek watershed.

Low and High Intensity Residential, Commercial / Industrial land use comprised 0.3 % of watershed (115 ac), located in the northeastern area only. The watershed is predominately forested (63.1 percent), with 4.6 percent wetlands and open water.

6.4 Human Impact from Acid Deposition

Acid deposition is expected to occur in the Piscataway Creek watershed, however rainfall pH data are difficult to collect and do not exist near Piscataway Creek. The closest available rainfall pH data come from the National Atmospheric Deposition Program /NTN station in Charlottesville, VA. Acid deposition occurred in the Charlottesville dataset, with weekly rainfall pH during the period from 1990 to 2003 averaging 4.35 SU (SD = 0.277, n = 428), with a minimum of 3.43 SU and maximum of 5.29 SU. According to an EPA web site (http://www.epa.gov/airmarkets/acidrain/index.html) the natural pH of rain is about 5.5.

One method to assess whether acid deposition adversely impacts low pH in a waterbody is to compare daily precipitation data from the Virginia State Climatology Office to DEQ ambient water quality monitoring field pH data. During the last DEQ water quality standards triennial review in 2003, DEQ filtered daily rainfall data for 1996 - 2003 according to water sample collection dates at DEQ ambient water quality monitoring stations that were within an approximate 15-mile radius of precipitation monitoring stations. Precipitation amounts and field pH values were graphed together and correlation factors calculated. The only discernable pattern was a general negative correlation of precipitation to pH and the majority of r-values were well below 0.5, which does not indicate a close correlation between the variables. This comparison is described in correspondence to USEPA Region III dated October 14, 2003 in Appendix B.
However the extent to which stream pH is decreased by acid deposition in Virginia cannot be decisively established. Significant human impact from acid deposition is inconclusive.

7.0 CONCLUSION

The following decision process is proposed for determining whether low pH values are due to natural conditions:

If slope is low (<0.50) AND
If wetlands are present along stream reach AND
If no point sources or point sources with minimal impact on pH AND
If nutrients are < typical background

- ❖ average (= assessment period mean) nitrate less than 0.6 mg/L
- ❖ average total nitrogen (TN) less than 1.0 mg/L, and
- ❖ average total phosphorus (TP) are less than 0.1 mg/L AND

If nearby streams without wetlands meet pH criteria,

THEN determine as impaired due to natural condition
→ assess as category 4C in next assessment
→ initiate WQS reclassification to Class VII Swamp Water
→ get credit under consent decree

Piscataway Creek exhibits low slope with significant wetlands, and large areas of forested land. These contribute large inputs of decaying vegetation, which produce organic acids and lower pH as they decay. These are not considered anthropogenic impacts.

Piscataway Creek exhibits low nutrient concentrations below national background levels in streams from undeveloped areas, which not indicative of human impact.

There are no permitted dischargers in the Piscataway Creek watershed. Residential / Commercial land use (0.3%) probably has no pH effect on the headwaters or tidal areas.

There is not a close correlation between precipitation amounts and field pH at DEQ ambient water quality monitoring stations. The only discernable pattern has been a general negative correlation of precipitation to pH and the majority of r-values were well below 0.5, which does not indicate a close correlation between the variables. However the extent to which stream pH is decreased by acid deposition cannot be conclusively determined.

A change in the water quality standards classification to Class VII Swampwater due to natural conditions, rather than a TMDL, is indicated for Piscataway Creek and its tributaries, from their headwaters to the confluence with the Rappahannock River.

8.0. Public Participation

DEQ performed the assessment of the Piscataway Creek low pH natural condition in lieu of a TMDL. Therefore neither a TMDL Technical Advisory Committee (TAC) meeting nor a public meeting was involved. Public participation will occur during the next water quality standards triennial review process.

9.0 References

Maptech, Methodology for Assessing Natural Dissolved Oxygen and pH Impairments: Application to the Appomattox River Watershed, Virginia. 2003.

SRCC (Southeast Regional Climate Center) http://www.dnr.state.sc.us/climate/sercc/products/historical/historical_va.html (Accessed 12/18/02)

USGS (United States Geological Survey), National Background Nutrient Concentrations in Streams from Undeveloped Areas. 1999.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 1998. Virginia. 1998.

VADEQ (Virginia Department of Environmental Quality), Virginia Water Quality Assessment 2002. Virginia. 2002.

Appendix A

Glossary

GLOSSARY

Note: All entries in italics are taken from USEPA (1998). All non-italicized entries are taken from MapTech (2002).

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

Ambient water quality. *Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.*

Anthropogenic. *Pertains to the [environmental] influence of human activities.*

Background levels. *Levels representing the chemical, physical, and Bacterial conditions*
that would result from natural geomorphological processes such as weathering or dissolution.

Best management practices (BMPs). *Methods, measures, or practices determined to be*
reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Clean Water Act (CWA). *The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is section 303(d), which establishes the TMDL program.*

Concentration. *Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).*

Confluence. The point at which a river and its tributary flow together.

Contamination. *The act of polluting or making impure; any indication of chemical, sediment, or Bacterial impurities.*

Designated uses. *Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.*

Dilution. *The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.*

Direct runoff. *Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.*

Discharge. *Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.*

Discharge permits (under VPDES). *A permit issued by the U.S. EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process wa s established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.*

Domestic wastewater. *Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.*

Drainage basin. *A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.*

Effluent. *Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.*

Effluent limitation. *Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.*

Existing use. *Use actually attained in the waterbody on or after November 28, 1975, whether or not it is included in the water quality standards (40 CFR 131.3).*

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Hydrologic cycle. *The circuit of water movement from the atmosphere to the earth and its*
return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.

Hydrology. *The study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.*

In situ. *In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.*

Margin of safety (MOS). *A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody (CWA section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the*
TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).

Mean. The sum of the values in a data set divided by the number of values in the data set.

MGD. Million gallons per day. A unit of water flow, whether discharge or withdraw.

Monitoring. *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

Narrative criteria. *Nonquantitative guidelines that describe the desired water quality goals.*

National Pollutant Discharge Elimination System (NPDES). *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

Natural waters. *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

Non-point source. *Pollution that originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.*

Numeric targets. *A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

Organic matter. *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized* *by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

Peak runoff. *The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.*

Permit. *An authorization, license, or equivalent control document issued by EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

Point source. *Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.*

Pollutant. *Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, Bacterial materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).*

Pollution. *Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act, for example, the term is defined as the man-made or man-induced alteration of the physical,*
Bacterial, chemical, and radiological integrity of water.

Public comment period. *The time allowed for the public to express its views and concerns regarding action by EPA or states (e.g., a Federal Register notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).*

Raw sewage. *Untreated municipal sewage.*

Receiving waters. *Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.*

Restoration. *Return of an ecosystem to a close approximation of its presumed condition*
prior to disturbance.

Riparian areas. *Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.*

Riparian zone. *The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.*

Runoff. *That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.*

Slope. *The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).*

Stakeholder. Any person with a vested interest in assessment of natural condition or TMDL development.

Standard. In reference to water quality (e.g. pH 6 – 9 SU limit).

Storm runoff. *Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

Streamflow. *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

Stream restoration. *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

Surface area. *The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

Surface runoff. *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

Surface water. *All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

Topography. *The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

Total Maximum Daily Load (TMDL). *The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.*

Tributary. *A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

Variance. A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.

DCR. Department of Conservation and Recreation.

DEQ. Virginia Department of Environmental Quality.

VDH. Virginia Department of Health.

Wastewater. *Usually refers to effluent from a sewage treatment plant. See also* ***Domestic wastewater****.*

Wastewater treatment. *Chemical, Bacterial, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.*

Water quality. *The Bacterial, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.*

Water quality criteria. *Elements of the board's water quality standards, expressed as constituent concentrations, levels, or narrative statements, representing a quality of water that supports a particular use. When criteria are met, water quality will generally protect the designated use.*

Water quality standard. *Provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law (§ 62.1-44.2 et seq. of the Code of Virginia) and the federal Clean Water Act (33 USC § 1251 et seq.).*

Watershed. *A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.*

Appendix B

CLASS VII RE-CLASSIFICATION LETTER TO USEPA USED IN LAST TRIENNIAL REVIEW

Dated October 14, 2003

ATTACHMENT III – CLASS VII RE-CLASSIFICATION LETTER USED IN LAST TRIENNIAL REVIEW

October 14, 2003

MEMORANDUM

TO: EPA Region 3
FROM: David C. Whitehurst
SUBJECT: Supporting Data for Proposed Class VII (Swamp Waters) pH Criteria

As required by 40 CFR ?131.20, the purpose of this memo is to provide supporting data and information for Virginia's proposed classification change for several water bodies within the state. The Virginia Department of Environmental Quality (DEQ) has adopted a revised numerical pH criterion for some waters of the southeastern portion of the state as an effort to reflect the natural conditions of those waters and as an aid for the appropriate assessment of these waters. This criterion change is allowed according to 40 CFR ?131.11. (b). (1). (iii).

These waters were classified by the Virginia Water Quality Standards as Class III Coastal and Piedmont Nontidal Waters (9 VAC 25-260-50), with a pH range of 6.0 to 9.0 as is the case for all classes of waters statewide. The amendments to 9 VAC 25-260-5 define Class VII waters as "…waters with naturally occurring low pH and low dissolved oxygen caused by:
(1) low flow velocity that prevents mixing and re-aeration of stagnant, shallow waters and (2) decomposition of vegetation that lowers dissolved oxygen concentrations and causes tannic acids to color the water and lower the pH." The proposed pH criterion for Class VII waters is 4.3 to 9.0. The proposed amendments are a change in the numerical criterion for a particular type or class of water body and not an alteration of designated uses. Aquatic life uses shall be maintained and required effluent pH limits of 6.0 - 9.0 shall be maintained for all discharges to Class VII waters.

The water bodies that are proposed for Class VII designation are frequently referred to as blackwater streams/rivers due to the characteristic dark color that is a result of staining by fulvic and humic acids. The water chemistry is generally characterized by low buffering capacity and high acidity. The pH in peat draining blackwater systems can range from 3.5 - 6 and in mineral soil draining systems from 4 - 7. The naturally occurring acidic conditions of Mid-Atlantic Coastal Plain blackwater streams is well documented in peer reviewed scientific literature (Appendices A, B and G). The US Environmental Protection Agency 1997 publication “Field and laboratory methods for macroinvertebrate and habitat assessment of low gradient nontidal streams” states that "Coastal plain streams are often naturally acidic due to the high concentration of humic and fulvic acids found in the water draining swamp soils. The pH of these streams most often ranges from 3.5 to 7.5." (Appendix B)

Ambient water quality monitoring field pH data for stations within waters that are proposed as Class VII is presented in Appendix C as is a photo representative of the water body. Where sufficient data was available, pH values were averaged for each monitoring station on a water body and graphed. Individual pH values for each monitoring station were also graphed. The majority (> 50%) of individual pH values were below 7.

In an effort to confirm that point source discharges were not contributing to the low pH values, the DEQ permitting database was queried for pH violations (pH< 6) at permitted outfalls located on the proposed water bodies (Appendix D). One facility had two compliance violations (failure to report pH), one facility had three violations for discharge over the upper limit for pH (pH> 9), and one facility for effluent discharge less than the lower require limit (pH<6). All of the discharges are less than 1.0 MGD and the discharges are to small tributaries to the proposed Class VII waterbodies.

At the request of EPA Region 3 for DEQ to demonstrate that proposed Class VII waters are not impacted by acid rain that would unnaturally lower pH, daily precipitation data from the Virginia State Climatology Office was compared to DEQ ambient water quality monitoring field pH data (Appendix E). Daily rainfall data for 1996 - 2003 was filtered according to water sample collection dates at DEQ ambient water quality monitoring stations that are within an approximate 15-mile radius of precipitation monitoring stations. Precipitation amounts and field pH values were graphed together and correlation factors calculated. The only discernable pattern was a general negative correlation of precipitation to pH and the majority of r-values were well below 0.5, which does not indicate a close correlation between the variables.

According to an EPA web site (http://www.epa.gov/airmarkets/acidrain/index.html) the natural pH of rain is about 5.5 and the average pH of rainfall for the southeast/south-central region of Virginia, where the proposed Class VII waters are located, is 4.6 (Appendix F). Due to the naturally acidic conditions and low acid neutralizing capacity of the Virginia Coastal Plains watersheds, they are considered to be sensitive to atmospheric acid deposition (acid rain) and the effects may either be ameliorated or exacerbated by the type of land use in the watershed. A joint pilot study of episodic acidification of first order blackwater streams in southeastern Virginia conducted by Virginia Commonwealth University and DEQ found significant differences between pH depression duration and magnitude. Study sites within undisturbed old growth watersheds showed the greatest pH depressions and study sites within deforested and agricultural watersheds exhibited less severe pH depressions (Appendix G).

Other states such as North Carolina have narrative and numerical criteria in their water quality standards that recognize some waters may have characteristics outside of the "normal" range established by statewide standards (Appendix H). In light of this and other information presented here, it is logical and necessary that Virginia alter its numerical criterion for pH to reflect the naturally occurring conditions within certain water bodies in the state.

Attachments